TECHNICAL REPORT 30

ENERGY LEVELS OF THE COMPOUND STATE OF N_2 NEAR 2.3 eV

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Contract Number: NOR-2584(00)

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Atomic and Molecular Sciences
Research and Development
Westinghouse Research Laboratories
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Approved R. E. Fox

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The vibrational excitation and the elastic scattering cross sections for electron impact on nitrogen molecules[1] exhibit structure in the energy range between 1.7 and 3.5 eV. This structure, consisting of up to five clearly resolved peaks, has been attributed[2] to the existence of a compound state centered about 2.3 eV. This letter reports the spacing of this structure to a higher accuracy than has been done previously in order to ascertain whether this structure bears any relationship to the vibrational structure of a state of N_2 from which the compound state could derive.

It was recently established that for the compound state[3] in H_2 around 12 eV, the spacing of the structure in the elastic cross section

(1) G. J. Schulz, Phys. Rev. 135, A988 (1964). This paper gives references to previous work. See also H.G.M. Heideman, C. E. Kuyatt, G. E. Chamberlain (to be published).

(2) A. Herzenberg and F. Mandl, Proc. Roy. Soc. (London) A270, 48 (1962). J.C.Y. Chen, J. Chem. Phys. 40, 3513 (1964).

(3) C. E. Kuyatt, S. R. Mielczarek, J. A. Simpson, Phys. Rev. Letters 12, 293 (1964). See also D. E. Golden and H. W. Bandel, Phys. Rev. Letters 14, 1010 (1965).

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is, within experimental accuracy, identical with the spacing of the vibrational levels of a nearby excited state from which this compound state derives. Taylor and Williams[4] have pointed out that such a behavior is to be expected in the case of the hydrogen molecule; however, it is not certain that this is the case for all types of compound states.

The experimental values shown in Table I were obtained on the double electrostatic analyzer described in Ref. 1. The electrons are made monoenergetic (half-width $\sim$0.06 eV) by passing them through a 127° electrostatic analyzer. The second electrostatic analyzer is adjusted to accept electrons which have been scattered at an angle of 72 degrees with an energy loss corresponding to the channel being studied. The energy dependence of the cross section of a given channel is exhibited on an X-Y recorder. Figure 1 shows the energy dependence of the elastic cross section (v = c) obtained in this manner. From such data and similar sweeps of the vibrational cross section (v = 1, v = 2, v = 3), the data for Table I are obtained. Generally the present results exhibit all the features reported in Ref. 1, i.e. the shift in the onset of the inelastic channels and the broadening of the inelastic peaks when higher vibrational states are excited.

The first two columns of Table I show the vibrational spacing of ground state, $X'\Sigma_g^+$, and the first excited state, $^3\Sigma_u^+$, as given by Herzberg.[5]

(4) H. S. Taylor and J. K. Williams, J. Chem. Phys. 42, 4063 (1965).

(5) G. Herzberg, "Molecular Spectra and Molecular Structure," D. van Nostrand, 1950.

The third column, marked "elastic channel (v = o)" shows the experimentally determined spacing of the structure in the elastic cross section for the first five peaks. The data given are the mean values of nine runs and have a confidence error of ± 0.02 eV associated with them. The remaining three columns show the spacing in the vibrational excitation of N_2 to the first, second, and third vibrational state. It should be noted that the spacing of the structure in the elastic cross section is, within experimental error, identical to that of the ground state and differs markedly from the vibrational structure of the A state.

The agreement between the spacing of the structure in the elastic cross section and the vibrational structure of the ground state leads one to believe that somehow the compound state N_2 derives from the ground state configuration. In view of the fact that the compound state usually lies at a lower energy than the parent state, this is a surprising conclusion.

Acknowledgment

The authors are indebted to H. S. Taylor for stimulating discussions.

Table I

Spacing of Levels, in eV

v - v	$X'\Sigma_g^+$	$A^3\Sigma_u^+$	Experimental			
			Elastic Channel V = 0	Inelastic Channels		
				v = 1	v = 2	v = 3
0 - 1	0.289	0.178	0.30	0.30	0.41	0.38
1 - 2	0.285	0.174	0.28	0.32	0.28	0.31
2 - 3	0.282	0.170	0.26	0.27	0.30	0.30
3 - 4	0.278	0.167	0.26	0.27		

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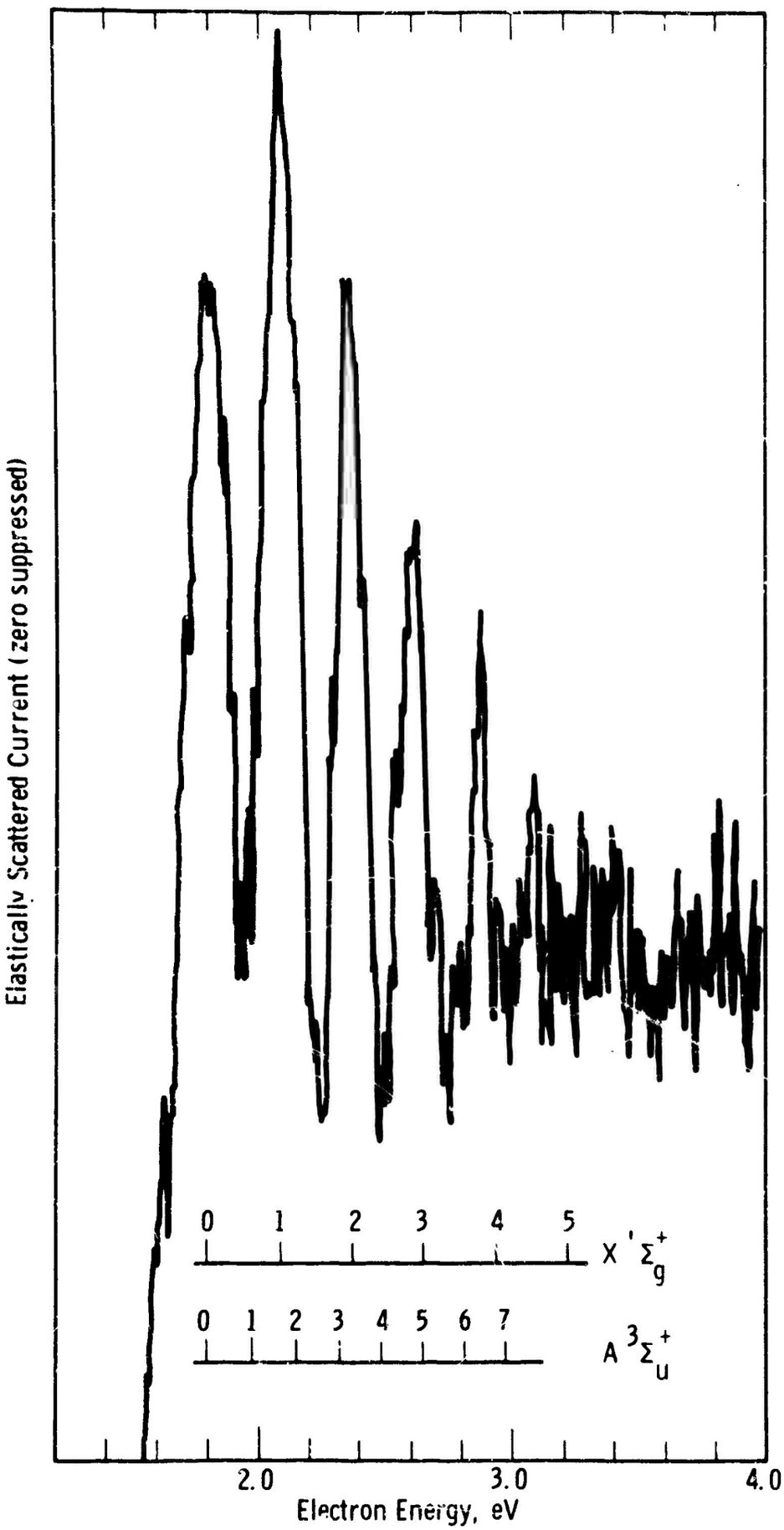

Elastic cross section in N_2 in the energy range of the compound state

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13 ABSTRACT
The energy levels of the compound state of N_2 around 2.3 eV have been determined from the structure in the elastic cross section. It is found that the spacing of this structure is in agreement with the vibrational spacing of the ground state of N_2.

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